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If OSHA is so bad, why is compliance so good?

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Since its inception twenty-five years ago, the Occupational Safety and Health Administration (OSHA) has been the subject of an intense public debate on its effectiveness. This article analyzes the determinants of establishment-level compliance with specific safety and health standards as a means of assessing the agency's effectiveness. The empirical results suggest that OSHA has had large impacts on business compliance behavior, despite its low regulatory profile. These results indicate that government regulatory agencies can substantially change private-sector behavior, even given limited regulatory resources.

1. Introduction

■ The Occupational Safety and Health Act of 1970 (OSHA) regulates conditions in private-sector establishments and has been one of the most controversial examples of social regulation of the past two decades. In one view, OSHA has been charged since its inception with imposing needlessly high costs on firms covered by its health and safety standards (Smith, 1976; Weidenbaum and DeFina, 1978).[1] In this view, OSHA is an onerous ogre that imposes costs on businesses with little benefit in terms of improved safety and health.

A second perspective casts OSHA as a "toothless tiger," unable to achieve its stated goal "to assure as far as possible to every working man and woman in the nation safe and healthful working conditions . . ." The failure of OSHA is ascribed to the small number of inspections it conducts relative to the total number of establishments

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[1] The headlines from the major business press during the early days of OSHA are indicative of this view: "In the Name of Safety: All Industry Willy-Nilly Has Become Lawbreakers," *Barron's,* August 7, 1972, pp. 11–18; "Where the Safety Law Goes Haywire," *Nation's Business,* June 1972, pp. 40–46; "New Job Safety Rules Perplex the Owners of Small Business: Needless Costs Cited," *Wall Street Journal,* February 20, 1973, p. 42.

covered by the act and the low level of fines received by inspected firms (see, for example, Lofgren (1989)).[2]

While both views of OSHA are ultimately related to its ability to improve safety and health outcomes, they turn on how responsive firms covered by OSHA are to inspection pressure. The "onerous ogre" OSHA view implies that firms are forced into compliance with costly standards by government enforcement, which in turn implies the existence of a credible threat of inspection and/or high penalties associated with violation. The "toothless tiger" view is premised on the existence of low inspection probabilities and meager penalties resulting in minimal incentives for compliance.

Aggregate data concerning OSHA enforcement activity would seem to support the toothless tiger view. In a given year, OSHA is able to conduct a very limited number of inspections. In 1991, it conducted a total of 42,113. The average fine levied by the agency is also minimal, equalling $600 per violation in 1991. The low frequency of follow-up inspections (about 5% of all inspections in 1991) suggests small incentives to comply with OSHA, even following an inspection, since the probability of receiving a follow-up inspection to check on compliance is minimal (Siskind, 1993).

This article suggests that a third story may explain both characterizations of OSHA. Based on a longitudinal sample of establishments in the custom woodworking industry, the article shows that establishments have limited incentive to comply with a specific set of OSHA standards. Nonetheless, the application of low levels of OSHA enforcement pressure seems to result in high levels of compliance among regulated establishments. As a result, the study indicates that establishments choose to comply with OSHA standards beyond what one would expect given low inspection probabilities and penalties. OSHA therefore seems to elicit establishment reactions as if it were an ogre even given relatively toothless enforcement.

The remainder of this article is divided into four sections. In Section 2 I present a methodology for testing OSHA's impact on compliance empirically. Section 3 then applies this methodology to data from the custom woodworking industry that provide a useful "laboratory environment" to test the basic compliance model. Section 4 extends the analysis further by modelling the determinants of compliance behavior. The article concludes with the implications of these findings for the more general question of OSHA performance.

2. Methodology and data

■ Economic analyses of regulatory compliance generally build on the model of crime set out by Becker (1968) and Stigler (1970). Criminal activity, or regulatory noncompliance, is a decreasing function of the penalty and the probability of being caught, and an increasing function of the return to crime, or the avoidance of costs arising from regulatory compliance. Compliance can therefore be increased either through more aggressive enforcement policies or by reducing the costs of complying with regulatory standards. Empirical tests for the relation of enforcement to compliance underlying OSHA (or other command and control regulatory systems similarly structured) require careful selection of an industry and specific regulatory standards and a method of systematically measuring compliance. This section describes the methodology for selecting an industry and standards in detail and the data employed in the empirical analysis.

[2] For example, following a safety disaster in North Carolina, *U.S. News and World Report* noted, "A tragic fire in a North Carolina chicken-processing factory has pointed up a national problem: too few safety inspectors in the workplace . . ." (September 16, 1991, p. 11).

□ **Criteria for industry selection.** To test most simply and directly the model described above, one requires an industry where first inspections are random events, that is, where the probability of receiving an initial inspection is relatively constant across all covered establishments. This condition implies that establishments have a fairly accurate estimate of being "hit" by an inspection and therefore a rational basis for making compliance choices based on that assessment, and that the pool of establishments inspected are representative of the larger industry from which they were drawn.

This initial condition does not exist in many industries regulated by OSHA. OSHA has pursued explicit targeting policies over its history, focusing on specific, high-risk industries and high-injury workplaces (see Wokutch (1990) for a discussion of OSHA targeting policies). These policies have subjected certain industries to intense pressure over specific periods, thereby making long-term estimates of inspection probabilities difficult for individual establishments. In addition to explicit targeting, OSHA enforcement is concentrated on certain types of workplaces, particularly unionized and large establishments, and to a lesser extent establishments that are part of larger companies (Weil, 1991, 1992). Thus, the chosen industry should also be one in which the impact of such de facto targeting is limited.

□ **Measuring compliance.** The true state of compliance with OSHA standards is unobservable. In theory, an establishment could be assessed as to its state of compliance with all pertinent safety and health standards at any point in time. In practice, such an assessment occurs only at the time of an OSHA inspection. During the course of an inspection, OSHA personnel survey a plant's operations and assess its compliance with standards. Each activity that does not comply with those standards is cited by the inspector and rated according to its severity and the number of workers potentially exposed to the violation (resulting in a total number of cited violations).

The number and severity of cited violations can be used as a proxy of the underlying state of compliance of the firm with OSHA standards. Compliance at time t can be defined as a dichotomous variable:

$$Compliance_{i,t} = 1 \quad \text{if } V_{i,t} < V^* \text{ (compliance)} \qquad (1)$$
$$= 0 \quad \text{if } V_{i,t} \geq V^* \text{ (noncompliance)}$$

where $V_{i,t}$ is the observed number of violations of designated OSHA standards for firm i, time t, and V^* is a threshold number of violations used to define whether or not compliance has been achieved (e.g., $V^* = 0$ if we define noncompliance as being cited for one or more violations of the designated standard). The value of V^* can be set according to production size (violations/employee), severity (number of serious violations of standards), or some combination of those factors.

In an ideal test of OSHA performance, certain types of standards used to measure compliance are also desirable. First, the set of safety and health standards under scrutiny must not have been appreciably changed over the period under study, and should have been consistently enforced by OSHA. This is not always the case, since there are many standards that have been refined or eliminated by OSHA or received varied enforcement scrutiny over time. Second, the OSHA standards under scrutiny should be associated with practices that differ from what would be undertaken by the firm in its own profit-maximizing interest.

The criteria for choosing a compliance measure outlined here require a standard-specific approach. This differs from compliance measures employed in the literature (Bartel and Thomas, 1985; and Gray and Jones, 1991a, 1991b), which use total violations cited in an inspection rather than those linked to specific OSHA standards as the compliance metric. The problem with these measures is that they may pick up shifting focuses of OSHA enforcement rather than the underlying state of compliance. Further, these measures require estimating the costs of complying with all relevant OSHA standards. Thus, aggregate measures of violations can confound analyses of the relations between enforcement and compliance.

□ **The custom woodworking industry.** Based on the criteria described above, this study uses a sample of establishments from the custom woodworking industry for evaluating OSHA performance. The custom woodworking industry is composed of firms producing wood cabinets, office fixtures, retail displays, and architectural (i.e., customized) cabinetry. The firms in this industry employ an average of 41 employees, although there are larger-scale establishments employing over 100 workers.

There are a number of advantages in selecting this industry. First, given the homogeneity of its product market, production technologies have a fairly high degree of similarity.[3] This is important in terms of designating a set of key OSHA standards (see below) and in limiting variance across establishments in the estimated costs of complying with chosen standards. Nonetheless, the industry is representative of a broader class of manufacturing industries in that its production processes require the machining, refining, assembly, and finishing of an entire product.

A second desirable characteristic is that the industry has received a modest—and therefore typical—level of attention from OSHA since 1972. OSHA conducted a total of 594 inspections in the industry between 1972 and 1991. Since there are a total of 621 establishments in the industry sample (see below), about 5% of covered establishments in the sector receive some kind of inspection in a given year. This rate of inspection is slightly higher than the overall rate for establishments in manufacturing, where OSHA conducted 12,131 inspections of 378,000 eligible establishments in 1990 (or a rate of .032).[4] Compliance behavior of establishments in this industry therefore provides information on how a typical manufacturing industry dominated by small establishments has adjusted to OSHA.[5]

A third advantage of using this industry for case study is the presence of a subset of OSHA standards that meet the requirements for standard selection described above: the safety standards related to machine-guarding and hand-held tools.[6] Evaluating compliance with these standards has a number of advantages. First, the standards date back to the inception of OSHA and have not been significantly modified throughout its 25-year history. This means that establishments in the sample have faced consistent requirements throughout the study period. Second, the standards are clear and do not require sophisticated monitoring (in contrast to health standards such as wood dust or formaldehyde, which require complicated air sampling and laboratory follow up). Third, the machine-guarding and hand-tool standards are subject to considerable scrutiny by OSHA inspectors. Based on the universe of inspections conducted from 1972 to 1991 in this industry, 43% of all violations cited are violations of these standards.

[3] Establishments in the industry produce "architectural woodwork" used most commonly in commercial building interiors, usually designed to particular specifications for a project. This contrasts with more mass-production-oriented segments of the industry, which often use different production techniques.

[4] Author's calculation based on establishment data from U.S. Department of Commerce (1993) and number of inspections from Siskind (1993).

[5] In contrast, a few manufacturing industries have been the object of intense OSHA scrutiny over the past 20 years. For example, blast furnace and basic steel products (SIC 331) received a total of 10,932 inspections in 1972–1991. Given the number of establishments in this SIC group (1,299 in 1990), a typical plant faces an annual probability of inspection of .42 (author's calculations based on inspection data from the OSHA IMIS dataset and U.S. Department of Commerce (1993) for number of establishments).

[6] See *Code of Federal Regulation,* Machinery and Machine Guarding Standards, Subpart O, 1910.211–1910.221; Hand and Portable Powered Tools and other Hand-Held Equipment, Subpart P, 1910.241–1910.245.

In a related vein, enforcement data indicate that OSHA inspectors examine compliance with these standards whether they are undertaking a safety or a health inspection. As a result, OSHA inspectors are both likely and able to accurately measure compliance levels during the course of most inspections.

Establishment compliance with machine-guarding and hand-tool standards is measured by counting the number of violations of these standards received at the time of an OSHA inspection to provide a measure of $V_{i,t}$. Following equation (1), an establishment is defined as in compliance with standards at time t if $V_{i,t}$ is less than V^*. Three definitions of compliance at t are employed, using $V^* = 0$, 1, and 2.

□ **Data.** The study draws on the Integrated Management Information System (IMIS) maintained by OSHA to track its enforcement activity. The IMIS contains complete records of all inspections conducted by the agency for the period 1972–1991 for federally administered OSHA programs, and partial records (beginning in the mid-1980s) for state-administered programs. Each inspection record contains comprehensive information on characteristics of the inspected workplace (e.g., establishment and company size, location, union status); characteristics of OSHA inspection activity (such as length and physical coverage of the inspection); and detailed information on each violation of safety and health standard (severity, number of workers exposed).

To create a sample for study from the custom woodworking industry, a list of 621 establishments was compiled using information from the two main industry associations in the custom woodworking industry. In order to create a complete longitudinal sample going back to 1972, the search list includes only establishments located in states with federally administered OSHA programs. Based on this list, a search of the OSHA database identified a total of 250 establishments that had received one or more OSHA inspections.[7] Data from the 250 inspected establishments are the basis of the following empirical analysis. For each establishment in the sample, a longitudinal file was created from the OSHA database, providing detailed histories of each inspection, which standards were violated, firm characteristics, and measures of inspection intensity and administrative status.

□ **Sample representativeness.** Because IMIS data covers only establishments that have been inspected, the sample of establishments may not be representative of the universe if there is systematic bias in how OSHA selects plants for inspection. Alternatively, if establishments are initially chosen through random processes, the sample of inspected establishments should be representative of the industry from which they were drawn.

OSHA inspections are instigated by programmed activity (arising from planned inspection programs), employee complaints, follow-up efforts, and by accidents involving fatalities or serious injuries to several workers. Programmed inspections by OSHA arise from an administrative process that attempts to randomize inspections for all eligible establishments within an industry and geographic region (U.S. Department of Labor, 1994). While 78% of all inspections in the sample were done on a programmed basis, 94% of first inspections arose from programmed activities. This suggests that the sample should be representative of the population of woodworking establishments.

[7] The OSHA IMIS database is organized on an inspection-level basis and does not include specific establishment- or firm-level identifiers. As a result, longitudinal samples must be assembled through matching procedures involving the use of multiple fields in the database (e.g., company name, address, location, SIC listing).

Table 1 provides overall characteristics for establishments and inspections in the sample. About 40% of the original list of establishments received at least one inspection during the 20-year period under study. Establishments are relatively small (41 employees on average), although this is somewhat larger than found for SIC 2431 (millwork), which averaged 34 employees in 1990 (U.S. Department of Commerce, 1993). Comparing the size distribution of inspected establishments at the time of first inspections with the Department of Commerce distribution of establishments for SIC 2431 indicates that OSHA conducted fewer inspections on plants with 1–49 employees (79% of first inspections) than that group accounted for in the industry as a whole (85% of establishments in SIC 2431). At the same time, OSHA conducted a higher percentage of

TABLE 1 Sample Characteristics, Custom Woodworking Industry, 1972–1991

Establishment-level Characteristics	Count or Mean
Total number of establishments inspected	250
Establishment size (number of employees)	41.1
	(56.4)
Company size (number of employees)	51.7
	(95.1)
Multiplant operation (% of establishments)	8.2
Total number of inspections received by establishment	
0[a]	371
1	116
2	46
3	31
4	27
5–10	30
Inspection-level characteristics	
Total number of OSHA inspections	594
Inspection type (% of total inspections)	
General	77.5
Complaint	7.6
Follow-up	12.6
Other	2.2
Administration (% of total inspections)	
Nixon	4.8
Ford	10.2
Carter	13.2
Reagan	57.9
Bush	13.9
Penalty levels (1987 dollars)	
Penalty/inspection	300.89
	(815.36)
Penalty/violation	76.59
	(120.19)
Penalty/serious violation	228.29
	(192.82)

Note: Standard deviations are in parentheses.
[a] Number of establishments in original list but not found in search of OSHA data (see text).

inspections on establishments with 50–99 employees than would be expected if first inspection targeting was entirely random (18% of first inspections on establishments that accounted for 9% of SIC 2431).[8] These discrepancies might arise from the omission of very small establishments (those with fewer than 11 employees) from OSHA targeting lists.

The random nature of initial inspection probabilities can be further tested by comparing inspection probabilities between union and nonunion plants. Many industries exhibit stark union/nonunion differences in the causes and frequency of inspections arising from increased exercise of employee rights by union workers, such as the right to initiate OSHA inspections through employee complaints (Weil, 1991, 1992). For the custom woodworking sample there is no statistically significant difference in the frequency of employee complaints triggering first inspections between union and nonunion establishments. Similarly, initial inspection probabilities do not differ significantly based on union status.[9] Thus, the sample taken as a whole is only somewhat biased toward larger, more stable establishments, primarily arising from the targeting pool used by OSHA.

3. Empirical results on compliance and enforcement

■ Predicting baseline compliance with an OSHA standard is straightforward. Assume that establishment i in industry j faces the decision of whether or not to comply with safety and health standards, where C_i represents the expenditures required to achieve compliance, p_j the perceived probability of inspection, and f_j the total fines if found in violation of standards. Compliance beyond what is in the profit-maximizing interest of the firm absent the standard is determined by relation of these factors relative to the point of indifference between compliance and noncompliance, where

$$C^* = (p_j/1 - p_j)^* f_j. \tag{2}$$

OSHA has placed little pressure on the custom woodworking industry historically. The sixth row of Table 1 presents the frequency of inspections for establishments in the sample. Over the 20-year period, 371 (or 60%) of all eligible establishments did not receive a single inspection. Only 88, or 14% of all eligible establishments, received three or more inspections between 1972 and 1991. As a result, the annual probability of inspection is about .048, and of receiving an initial inspection .022.[10]

To assess the costs of complying with OSHA machine-guarding and hand-tool standards, I surveyed five custom woodworking firms. The respondents all reported that compliance costs primarily involve one-time capital expenditures for bringing existing machinery into compliance with OSHA machine-guarding and hand-tool standards. In addition, there are secondary costs associated with training operators on safe operating procedures and specifics related to compliance. Finally, while the OSHA standards set out, in part, design requirements for new machinery, surveyed employers

[8] Based on author's calculation using OSHA IMIS and data on SIC 2431 in U.S. Department of Commerce (1993).

[9] Complaint inspections constitute 5.8% of all first inspections among union plants and 7.3% of all nonunion first inspections. The annual probability of receiving an initial inspection is .024 for union and .018 for nonunion establishments. A χ^2 test of the overall union/nonunion distribution of inspections reveals a disproportionate share of union inspections, suggesting a union enforcement effect following initial inspections.

[10] The annual probability of inspection equals the observed number of annual first inspections divided by the total number of establishments in the eligible inspection universe. This probability is relatively constant throughout the sample period, ranging from a low of .01 between 1977 and 1981 to a high of .050 in the late 1980s.

reported that separate machine-guarding equipment must often be purchased with new table saws, molders, presses, and for equipment not explicitly mentioned in the machine-guarding standards.[11] In addition, many manufacturers in the industry purchase used equipment, which can require retrofitting.

Based on the survey of firms (all of which were in operation previous to passage of OSHA), the predicted expenditures for complying with machine-guard and hand-tool standards range between $5,000 and $15,000 (in 1987 dollars), varying primarily on the scale of operations.[12] Estimates for the cost of retrofitting vary by the type of equipment, ranging from table saws, which may cost $350–$500 to equip with guards, to wood shapers, mortising equipment, and lathes, which can cost $1,500 per machine. Thus, capital-related compliance costs vary with the mix and number of saws, planers, joiners, boring equipment, power presses, and so forth that a manufacturer must either adapt or purchase in order to achieve compliance. These estimates reflect capital expenditures incurred by a typical woodworking firm, but do not include costs related to operator training, managerial time spent on interpreting and implementing OSHA requirements, or incremental costs associated with purchasing new or used equipment over time.

Given that the probability of a plant's being inspected over the entire study period is .4, and that the expected fine per inspection (in 1987 dollars) equals $300, and assuming for the moment that inspections in the industry are random events, equation (2) predicts that if the cost of complying with machine-guarding and hand-tool standards is greater than $200 (the estimated value of C^* given p_j and f_j), establishments should choose not to comply beyond what is in their profit-maximizing self-interest. Since the estimated compliance costs dwarf this value of C^*, one would predict low levels of compliance with machine-guarding and hand-tool standards in the sample. If the chance of inspections remains low, the above estimates also suggest little reason for compliance to improve, even given subsequent OSHA inspection activity.

Table 2 presents the observed frequency of compliance and noncompliance with machine-guarding standards, given three definitions of compliance. Inspections are grouped in order of their occurrence for an establishment (i.e., first inspection, second inspection, etc.). The table provides compliance rates for each inspection number, measured as the percentage of inspections in establishments that were found in compliance.

Forty-two percent of all plants receiving their first inspection complied with machine-guarding standards (where compliance is defined as having no cited violations of the standards). At the time of the second inspection (for plants receiving two or more inspections), compliance had risen to 65.7% of all inspections. Compliance continues to improve for plants receiving subsequent inspections. The other columns in Table 2 demonstrate a similar pattern of improving compliance given more "lax" definitions of compliance (i.e., where compliance is defined as having fewer than two or fewer than three violations of the standards).

These results imply a high level of initial compliance (between 42% and 51%, depending on the definition of compliance). The table also demonstrates that compliance improves markedly as establishments receive subsequent inspections. Since internal factors related to compliance should be relatively constant between inspections, establishments appear to be responsive to external regulatory pressure in contrast to predicted behavior given observed p_j, f_j, and C_j.

[11] A survey respondent noted that although the OSHA standards set out guarding requirements for newer machines, "No manufacturer, that I am aware of, will certify that their equipment meets OSHA specifications, and say that safety is our [woodworking firms] responsibility."

[12] Ongoing capital costs related to expansion also vary according to the age of existing equipment, and the relative attractiveness of purchasing new equipment that complies with OSHA or retrofitting used equipment purchased in secondary markets.

TABLE 2 Observed Compliance with Machine-guarding Standards by Number of Inspections

Sequence Number of Inspection	Compliance = <1 Violation (% of Establishments in Compliance)	Compliance = <2 Violations (% of Establishments in Compliance)	Compliance = <3 Violations (% of Establishments in Compliance)
1 (N = 250)	41.6	48.0	50.8
2 (134)	65.7	68.7	76.1
3 (88)	70.5	75.0	76.1
4 (57)	61.4	66.7	71.9
5 (30)	73.3	76.7	83.3
6 (16)	56.3	75.0	75.0
7 (10)	90.0	90.0	90.0
8 (5)	60.0	80.0	80.0
9 (3)	100.0	100.0	100.0
10 (1)	100.0	100.0	100.0

Note: Each cell represents the percentage of all inspections of a given sequence number where establishments were found in compliance with machine-guarding and hand-held tool standards. Total number of inspections per sequence number is listed in the first column.

□ **Inspection probabilities.** Observed compliance among custom woodworking shops shown in Table 2 does not necessarily mean that custom woodworking shops are acting counter to their profit-maximizing interest, however. A more careful analysis of the underlying probabilities of inspection is necessary in order to assess whether inspected establishments truly face the low chance of being inspected implied by the above analysis.

Once an establishment has been inspected by OSHA, the probability of inspection conceivably changes dramatically. If, for example, OSHA sought to ensure compliance among establishments that violated OSHA standards at the time of the first inspection, the probability of receiving a follow-up inspection would be close to 1.0. On the other hand, if OSHA does no follow up, the probability of subsequent inspections should be equal to initial inspection probabilities, with multiple inspections arising as a result of strictly random processes. A comparison between the observed distribution of inspections received per establishment and the expected number of inspections arising from a randomized inspection process demonstrates that the observed distribution arises from a nonrandom process.[13]

[13] The expected distribution is generated by multiplying a probability distribution arising from the binomial process $f(x) = (n!/x!(n - x)!)p^x(1 - p)^{n-x}$, where $p = .05$, $x = 0, 1, \ldots, n$; $n = 10$ (where n is

Of the 344 inspections with sequence number 2–10, 71 (20.6%) are listed officially as arising from OSHA follow-up efforts, 29 (8.4%) from employee complaints, and the remaining 244 (70.9%) from programmed inspections. Analysis of data on subsequent inspection probabilities, however, suggests that the majority of these inspections constitute de facto if not de jure follow-up inspections.

Table 3 compares the number of violations of machine-guarding standards in first inspections for establishments receiving single and multiple inspections. Because larger establishments tend to receive more violations because of their size, and because the sample as a whole is somewhat biased toward larger plants, Table 3 also reports these means for smaller plants (with 1–49 workers) and larger plants (those with more than 50 workers). The results indicate that establishments receiving more than one inspection received a higher number of violations in their first inspection than establishments that received only one inspection. For example, the mean number of violations cited in the first inspection for plants that were inspected twice was double the level of the mean violations for establishments inspected only once (6.98 versus 3.08). These differences in initial violations persist within the two size groups (2.73 versus 6.84 for small plants and 4.75 versus 7.63 for large plants).

If establishments receiving multiple inspections tend to have a higher number of OSHA violations in initial inspections, OSHA might be strategically choosing to conduct follow-up investigations on noncompliers more aggressively. This in turn implies that the probability of receiving an inspection given a violation of machine and hand-tool standards in a previous inspection is greater than the probability of receiving a subsequent inspection absent a violation in the previous inspection.

Table 4 presents the conditional probability of receiving an inspection given previous inspection history. The results concerning second inspections show that inspection probabilities increase given violations in the first inspection. The probability of receiving a second inspection given a violation in inspection 1 was equal to .416 (column 2 in the table). In contrast, the probability of receiving a second inspection for an establishment having no previous violations of standards is equal to .136 (see column 3).

The pattern of conditional inspection probabilities is anomalous, however, for inspections subsequent to second-round inspections. Specifically, the probability of receiving a third inspection is lower for establishments having a violation in the second inspection (.239) than for establishments that did not violate OSHA standards in the second inspection (.399). This pattern continues in subsequent inspections, suggesting that inspectors tend to return to establishments for reasons other than affecting compliance behavior,[14] or as the result of other agents triggering inspections.[15] Nonetheless, Table 4 indicates that the conditional probability of receiving an inspection grows once one has been inspected for the first time. This is shown in column 4, which presents the probability of receiving an additional inspection, regardless of the number of violations previously cited.[16]

the maximum number of inspections/establishment received in the sample), by the total number of inspections. The χ^2 from comparing the observed and expected distributions far exceeds the value needed to reject the H_0 that the two distributions arose from the same population.

[14] Studies by Bardach and Kagan (1982) describe the existence of standard operating procedures and other bureaucratic patterns to explain this type of regulatory behavior (e.g., inspectors return to sites that are "easier" to inspect or where they face less hostility from employers, both of which may tend to have better-than-average compliance).

[15] For example, the anomalous probabilities might arise in part from the tendency of larger, unionized plants to trigger a disproportionate share of complaint inspections, which tend to be far less comprehensive than programmed inspections and therefore less likely to surface violations.

[16] The plants in the sample also experienced long lag times between first and final inspections. The mean elapsed time between first and final inspection for plants receiving two inspections equals 2.5 years.

TABLE 3 **Number of Violations of Machine-guarding Standards for Establishments Receiving Single and Multiple Inspections**

Total Number of Inspections Received by Establishment	Mean Violations Cited in First Inspection: Overall	Mean Violations Cited in First Inspection: 1–49 Workers	Mean Violations Cited in First Inspection: 50+ Workers
1	3.08	2.73	4.75
	(5.40)	(5.48)	(5.14)
2	6.98	6.84	7.63
	(8.32)	(9.90)	(10.60)
3	6.55	6.54	7.67
	(8.62)	(8.50)	(10.17)
4	4.74	4.26	10.0
	(5.71)	(4.39)	(12.49)
5–10	8.23	5.83	15.13
	(10.44)	(5.83)	(16.94)

Just as the probability of receiving an inspection is conditional on previous enforcement activity, the expected fine per inspection changes according to the sequence number of the inspection, as shown in the final column of Table 4. The mean penalty for establishments receiving a first inspection where a violation was cited (in 1987 dollars) is $591.[17] Mean penalties per inspection increase to $646 in the second inspection, fall to $601 in the third inspection, and then rise again until the seventh inspection. While OSHA's penalty policies become more stringent as the number of inspections increases, they do not rise in the steep fashion required by a "strategic" penalty policy specifically aimed at inducing compliance (Polinsky and Rubinfeld, 1991), or even to the levels available under the law (see below).

□ **Predicted impacts of OSHA on compliance.** An establishment deciding whether or not to comply with OSHA standards faces a sequential series of choices, based on assessed probabilities, expected fines, and compliance costs. The more refined estimates presented above can be used to predict compliance behavior by a typical establishment in the custom woodworking industry. If we assume that establishments have information on the probability of first and subsequent inspections, and on penalty levels, we can represent the decision problem for the establishment at inspection sequence number n as

$$\text{Comply if} \quad C_i < (p_n \mid n - 1/(1 - [p_n \mid n - 1]))^* f_{n-1}, \tag{3a}$$

$$\text{Do not comply if} \quad C_i > (p_n \mid n - 1/(1 - [p_n \mid n - 1]))^* f_{n-1}. \tag{3b}$$

Elapsed time grows to 10.4 years for plants receiving five inspections, and to 13.4 years for the three plants that received a total of nine inspections. If all compliance costs are one-time capital expenditures, these lags would suggest misallocation of OSHA enforcement resources, in that one would desire the agency to assure compliance in a relatively short period and then leave the plant alone. Alternatively, the presence of operating-cost elements to compliance or increases in the scale of production raises the risk of a plant's moving out of compliance, making ongoing inspection a more reasonable strategy.

[17] Penalty levels are calculated for those inspections where violations were detected. If all inspections are included (i.e., those with and without violations), mean penalties per sequence number actually fall as the sequence number increases, reflecting the larger percentage of inspections where no violations are detected and therefore no penalties are assessed.

TABLE 4 Derived Inspection Probabilities and Penalties Given Previous Enforcement Outcomes

Sequence Number of Inspection	Probability of Inspection Given Violation in Previous Inspection	Probability of Inspection Given No Previous Violation	Probability of Additional Inspection Given Previous Inspection	Mean Penalties Received Given Violation (1987 dollars)[a]
1[b]	.440	.440	.440	590.50
2	.416	.136	.552	645.51
3	.239	.399	.638	600.71
4	.182	.466	.648	717.59
5	.193	.333	.526	1,630.15
6	.167	.367	.534	2,291.44
7	.188	.438	.626	1,388.30
8	.100	.400	.500	498.48
9	.20	.4	.60	.0
10	0	.33	.33	.0

Note: Inspection probabilities calculated on the basis of observations presented in Table A1.
[a] Mean penalties calculated for inspections with violations only.
[b] Baseline probability of receiving a first inspection during the 1972–1991 study period. See text for discussion of this issue.

The conditional probabilities and mean penalties lagged by one inspection from Table 4 can be used in a decision framework where the establishment faces a sequence of choices on whether to comply or not comply and face the chance of an additional inspection and increasing penalties. Applying these estimates to a median plant facing a sequential decision-making problem[18] leads to the same prediction of compliance behavior as found in the simpler analysis described above: the expected cost of not complying, risking detection, and facing penalties at the second and subsequent inspections are far lower than selecting voluntary compliance, even in the face of increasing conditional probabilities of follow-up inspections and growing penalty levels.[19]

One problem with using actual penalties received by plants in the sample is that these penalties understate the potential penalties faced by noncompliers—willful or repeat violations of cited standards can be subjected to OSHA's highest penalty levels. In the period under study, these could amount to $10,000 for each violation.[20] Applying

[18] The decision problem is laid out as a sequence of compliance decisions alternating with a random chance of inspection given the conditional probabilities (Table 4). The payoffs for different combinations of compliance choices and inspection occurrences are based on expected total penalties and, where appropriate, a cost of compliance of $5,000.

[19] The prediction of noncompliance is made by "folding back" the decision tree from the final compliance decision following inspection 9 to the initial compliance decision previous to receiving any inspection. A firm at the time of the initial compliance decision faces an expected cost of $733 from choosing noncompliance (arising from the lower expected cost of noncompliance in inspection rounds 2 through 9) versus $5,000 for choosing to comply immediately.

[20] Occupational Safety and Health Act, Section 17(a). In addition, the act states, "Any employer who fails to correct a violation for which a citation has been issued . . . within the period permitted for its correction . . . may be assessed a civil penalty of not more than $1000 for each day during which such failure or violation continues" (Section 17(d)).

these far higher potential penalties to the sequential compliance decision leads to far higher likelihood of compliance at an early stage.[21] Thus, if one takes into account increasing inspection probabilities and the possibility of steep penalties for noncompliance, the pattern of compliance found in Table 2 is more explicable, but requires that establishments assume far more draconian penalty policies than occur in practice.[22]

4. Modelling enforcement and compliance

■ Observed compliance with OSHA standards is a function of a number of factors other than inspection pressure. Equations (3a) and (3b) predict that compliance with standards by a firm will be determined by government pressure, the cost of compliance given production and work organization, and by other correlated factors that raise the costs of noncompliance, such as company size, multiplant status, and unionization. In addition, measures of compliance may be affected by the intensity of inspection activity itself, where more intensive inspections detect higher rates of violations (and therefore reduce the probability that an establishment will be found in compliance).

Given these potentially confounding factors, I constructed a model to predict establishment-level compliance given differing levels of OSHA inspection activity, establishment- and firm-level characteristics, and a series of controls for inspection intensity and administrative policies. In order to measure the independent impact of enforcement on compliance, a logit model can be used to predict compliance for plant i at time t, where

$$K_{i,t} = \beta_0 + \beta_1 INSP2_{i,t} + \beta_2 INSP3_{i,t} + \beta_3 LNHOURS_{i,t-1} + \beta_4 LNPENAL_{i,t-1} + \beta_5 LNSIZE_{i,t} + \beta_6 LNCOMP_{i,t} + \beta_7 UNION_{i,t} + \beta_8 MULTI_{i,t} + \beta_9 COMPLNT_t + \beta_{10} FOLLOW_t + \beta_{11} YEAR + \beta_{12} SIC + \beta_{13} TOTINSP_i + \epsilon_{i,t},$$

where

Dependent variable

$K_{i,t}$ = Observed compliance of establishment i at time t (1 if in compliance)

Independent variables

$INSP2$ = Dummy variable for second inspections received by a plant (1 for second and subsequent inspections)

$INSP3+$ = Continuous variable for third, fourth, and subsequent inspections (0 if first or second inspection, 1 if third, 2 if fourth, etc.)

$LNHOURS$ = Natural logarithm of total inspection hours up to but not including the present inspection

$LNPENAL$ = Natural logarithm of total penalties received by plant up to but not including present inspection (1987 dollars)

[21] Specifically, assuming that a plant is initially assessed \$300 for noncompliance in the first inspection, and that the penalty increases in \$5,000 increments beyond the first inspection for continued noncompliance, a risk-neutral plant would be essentially indifferent between compliance and noncompliance at the second inspection and would choose compliance beyond the second inspection.

[22] OSHA was quite reluctant to invoke maximum penalties during the period under study: the highest penalty for an inspection received by any plant in the sample was \$9,200 (1987 dollars). Only 7% of all inspections involved penalties of more than \$1,000. Thus, establishments cited in successive inspections for violations of machine-guard/hand-tool standards seldom received anywhere near the maximum penalty.

LNSIZE = Natural logarithm of establishment size (number of employees)

LNCOMP = Natural logarithm of company size (number of employees)

UNION = Dummy variable for union status of establishment (1 if union)

MULTI = Dummy variable for single versus multiplant company (1 if multiplant)

COMPLNT = Dummy variable for inspection initiated by employee complaint (1 if employee complaint)

FOLLOW = Dummy variable for inspection classified by OSHA as a follow up (1 if follow up)

YEAR = Nineteen dummy variables to capture changes in OSHA administrative policy over time

SIC = Five industry dummy variables to capture the impact of targeting policies in related industry groups and other potential threat effects

TOTINSP = Total number of inspections received by the establishment.

The model employs three direct measures of OSHA enforcement activity for each plant in the sample. First and foremost, we are interested in whether the observation represents a first, second, or subsequent inspection. The vast majority of OSHA inspections are done on a surprise basis (advance notice to employers was given in only two of the 594 inspections in the sample). As a result, an inspection conducted at time t measures the willingness of plant i to comply at $t - 1$ (that is, just previous to inspection).

The impact of the first OSHA inspection in fact measures the base level of compliance promoted by OSHA absent any inspection activity as well as the private incentives for compliance. That is, establishments will choose their individual level of compliance depending on their internal gains from compliance (direct savings in lost time, decreased turnover, worker compensation costs) as well as their response to external pressures. However, the second and subsequent inspections directly measure the impact of OSHA, since the plant has already chosen its optimal allocation. For this reason, if we wish to evaluate the impact of OSHA on compliance behavior, we are most interested in what happens after the first inspection.

Since the initial inspection represents a baseline to gauge changes in compliance, I use a dummy variable structure to capture the impact of the second inspection on compliance (where *INSP*2 = 1 for second and subsequent inspections) relative to the level of compliance found in the first inspection (where *INSP*2 = 0). A continuous variable (*INSP*3+) captures the incremental effects of subsequent inspections on compliance.

Current compliance behavior should also be affected by the past experience of the plant with OSHA in regard to penalties and enforcement intensity. Past penalties received by the establishment are captured in the total amount of fines levied on the firm up to but not including the present inspection (*LNPENAL*).[23] Increases in this lagged variable should raise the probability of compliance, *ceteris paribus*. In a related vein, the total time spent in OSHA inspections up to but not including the present inspection

[23] Another way of regarding accumulated time and penalties as determinants of current compliance behavior is to adopt a "behavioral" approach to firm behavior, in which regulatory response takes place over time given the need for internal learning by managers (see Cyert and March, 1963; Gray and Scholz, 1990).

(*LNHOURS*) is included as a lagged variable to capture past inspection experience of the establishment.

In addition to these direct enforcement measures, two other inspection-related variables, *COMPLNT* and *FOLLOW*, are included to control for the impact of nonprogrammed inspection triggers on measured compliance. The impact of OSHA-designated follow-up inspections (*FOLLOW*) is of particular importance, since these inspections are focused on checking for compliance with previously cited violations.[24]

Compliance behavior is also potentially a function of plant or firm characteristics that might also be correlated with OSHA inspection activity. Most important, plant and firm size have been shown in a number of studies to be positively correlated with progressive safety and health practices, where large firms are more likely to invest in training and capital equipment and have explicit safety and health policies relative to smaller firms (Sims, 1988; Smith, 1979). Since OSHA also tends to place more emphasis on inspecting or reinspecting larger plants and multiplant firms, these characteristics must be explicitly controlled (Weil, 1991, 1992). Union status is also controlled for because of its potential impacts on plant-level compliance behavior (Bacow, 1980).

Administrative policies pursued by OSHA are potentially correlated with observed compliance over time for reasons similar to those regarding inspection intensity. For example, in the Ford administration, OSHA's director Morton Corn placed considerable emphasis on health-related violations, as did the Carter administration's Eula Bingham. The Reagan administration substantially decreased inspection intensity through its "record inspection" program (Ruser and Smith, 1988). Year dummy variables are used to control for changes in the overall intensity of the larger OSHA program over the study period.[25] Finally, two variables are included in the model to control for other unmeasured correlates with compliance. SIC dummy variables are used to control for industry effects. A variable measuring the total number of inspections ultimately received by the establishment (*TOTINSP*) is also included in some specifications to capture correlates arising from the systematic biases in inspection targeting discussed in Section 2 and to control for establishment-level fixed effects (following Grey and Jones, (1991a)).

□ **Empirical results.** Table 5 presents the mean values and standard deviations of all variables and estimated coefficients and standard errors. In specifications 1a and 2a, an establishment was classified in compliance if there were no detected violations of machine-guarding and hand-tool standards (i.e., $V_{i,t} < 1$), whereas in 1b and 2b, an establishment was considered in compliance if it had one or fewer violations ($V_{i,t} < 2$). For each definition of compliance, results are also presented for two specifications, one including *FOLLOW* to control for the impact of explicitly designated follow-up inspections on compliance, and one without this variable.

The coefficients of greatest interest are those directly associated with enforcement: *INSP*2, *INSP*3+, *LNHOURS*, and *LNPENAL*. The positive coefficients for *INSP*2 imply a large initial OSHA enforcement effect on the probability of compliance with key industry standards, *ceteris paribus*. The estimates are statistically significant, and remain positive (although decreasing somewhat in magnitude) given the two different definitions of compliance. The coefficients for *INSP*3+ variables, while also positive, are small and lack statistical significance, indicating limited enforcement impacts beyond the second inspection.

[24] The model relies on enforcement variables determined in advance of current inspection activity. As such, they can be regarded as exogenous to the compliance relationship being estimated.

[25] The use of dummy variables to capture specific presidential administrations rather than year dummies does not change the reported results in size or significance.

TABLE 5 **Determinants of Compliance with Machine-guarding Standards in Custom Woodworking, 1972–1991**

Variable	Mean	(1a)	(1b)	(2a)	(2b)
*INSP*2	.58	1.586**	1.141**	1.078**	.686*
	(.50)	(.314)	(.343)	(.301)	(.326)
*INSP*3+	.78	.016	.179	.060	.198
	(1.38)	(.131)	(.147)	(.138)	(.149)
LNHOURS	2.07	.093	−.008	.237	.127
	(.99)	(.163)	(.171)	(.172)	(.177)
LNPENAL	5.14	.543**	.221	.620**	.374*
	(.96)	(.140)	(.156)	(.151)	(.163)
LNSIZE	3.33	.148	.153	.369	.300
	(.87)	(.450)	(.463)	(.620)	(.617)
LNCOMP	3.42	−.631	−.597	−.855	−.773
	(.93)	(.436)	(.449)	(.608)	(.602)
UNION	.56	.610*	.566*	.450	.370
	(.48)	(.248)	(.266)	(.247)	(.260)
MULTI	.09	.288	.349	.383	.456
	(.29)	(.568)	(.593)	(.626)	(.639)
COMPLNT	.08	.086	.546	.371	.695
	(.27)	(.403)	(.413)	(.408)	(.410)
FOLLOW	.13		3.921**		3.463**
	(.34)		(.634)		(.677)
YEAR dummies [19]		X	X	X	X
SIC dummies [5]		X	X	X	X
PLANT dummies [9]		X	X	X	X
Log likelihood		593.8	525.0	581.5	534.0
Number of observations		579	579	579	579

* Statistically significant at the 5% level.
** Statistically significant at the 1% level.
Note: Dependent variable in logit equals 1 if firm is in compliance with machine-guarding and hand-held tool standards at time of inspection, where: (1a, 2a) compliance = 1 if $V_{i,t} < 1$; (1b, 2b) compliance = 1 if $V_{i,t} < 2$. Each specification also includes an intercept term. Standard errors are in parentheses.

If OSHA influences establishment behavior, the probability of compliance with key standards should increase with each additional inspection. Thus, while the initial level of measured compliance (at $n = 1$) reflects optimal internal allocations of capital and labor as well as the impact of OSHA pressure, $\Delta p(K) = p(K_{n+1}) - p(K_n)$ represents a "clean" measure of the impact of additional OSHA inspections on compliance behavior.

Table 6 uses logit coefficients from Table 5 to predict compliance given changes in the number of inspections received by establishments when all other variables are held constant at their mean levels. The impact of various factors on the probability of compliance given logit estimates from model 1a of Table 5 are presented in column 2 of Table 6, while those using estimates from 1b are shown in column 3 (which include a dummy variable for follow-up inspections).

Table 6 demonstrates that the probability of compliance increases appreciably with initial OSHA inspection pressure (i.e., $\delta p(K)/\delta N > 0$, where N is the inspection sequence number). At the time of the first inspection, the estimated probability of compliance is .19 under model 1a. Predicted compliance jumps to .67 under model 1a as a result of an additional inspection, holding other variables constant at their means and

Table 6 Predicted Probability of Compliance with Machine-guarding Standards in Custom Woodworking

Variables	(1a)	(1b)
OSHA Enforcement		
Baseline predicted compliance level[a]	.580	.604
Impact of inspections[b]		
1st inspection	.188	.348
2nd inspection	.671	.656
3rd inspection	.734	.713
4th inspection	.773	.759
5th inspection	.800	.798
6th inspection	.821	.831
Impact of accumulated penalties[c]		
At mean	.727	.683
One standard deviation below mean	.613	.635
One standard deviation above mean	.817	.727
Impact of accumulated inspection hours[c]		
At mean	.727	.683
One standard deviation below mean	.708	.681
One standard deviation above mean	.745	.684
Follow-up inspection[c]		
No follow-up, 2nd inspection	—	.564
Follow-up, 2nd inspection	—	.985
Organizational		
Baseline predicted compliance level[a]	.580	.604
Unionization[d]		
Nonunion	.484	.516
Union	.633	.653
Impact of establishment size[d]		
One standard deviation below mean	.548	.572
One standard deviation above mean	.611	.636
Impact of multiple plant operations[d]		
Single plant firm	.574	.597
Multiplant firm	.642	.678

[a] Evaluated at mean values for all variables in the model.
[b] $INSP2 = 0$, $INSP3+ = 0$ for first inspection; $INSP2 = 1$, $INSP3+ = 0$ for second inspection; $INSP2 = 1$, $INSP3+ = 1$ for third inspection, etc.; *LNPENAL* increased by \$50/inspection after first; *LNHOURS* increased by 10 hours after first; all other variables held at mean values.
[c] Assumes second inspection ($INSP2 = 1$, $INSP3+ = 0$); all other variables held at means.
[d] Evaluated at mean values for all variables in the model except for independent variable analyzed.

assuming accumulated penalties of \$50 and inspection time of 10 hours.[26] This represents an enormous increase in compliance, where $\Delta p(K) = .48$ for model 1a, implying that compliance more than triples by the time that plants are inspected again. The

[26] The incremental values used for *LNHOURS* and *LNPENAL* are lower-bound figures to reflect realistic increases in these variables that come from repeat inspections, while providing a conservative basis for compliance estimates.

sizable compliance effects arising from second inspections exceed even those initially reported in Table 2.

An additional inspection beyond the second inspection results in further, but much smaller increases among remaining establishments, with overall predicted compliance reaching .73. While the enforcement effect diminishes with each subsequent inspection ($\delta^2 p(K)/\delta^2 N < 0$), OSHA enforcement engenders continued responsiveness up to the point that the probability of compliance reaches .82 at the sixth inspection.

Estimated enforcement impacts on compliance are moderated when I include in the model a separate variable controlling for the presence of follow-up inspections (1b in Table 6). Model 1b still finds striking predicted OSHA compliance effects, but they more closely reflect those actually observed in Table 2 than those found in the estimates generated by model 1a: It predicts a compliance probability at the time of the first inspection of .35, which then jumps to .66 at the time of the second inspection. Once again, the estimated compliance probabilities increase far less strikingly beyond the second inspection, rising from .71 in third inspections up to .83 at sixth inspections. These results more closely parallel those found in Gray and Jones (1991b), who find a similarly large impact of second inspections on the overall number of violations found in first OSHA inspections.[27]

Accumulated past penalties (*LNPENAL*) also have large and statistically significant impacts on current compliance behavior in all four models in Table 5. The magnitude of these effects is large: increasing the accumulated penalties from the mean penalties given the second inspection to one standard deviation above the mean leads to a .09 increase in predicted compliance drawing on model 1a, and a .05 increase using model 1b. While accumulated past time in inspection (*LNHOURS*) is also positively related to compliance, its small size and lack of significance indicates that past enforcement time has little impact on compliance.[28]

The *FOLLOW* variables in models 1b and 2b of Table 5 imply that the presence of an OSHA follow-up inspection has a major impact on compliance. Using the coefficient from model 1b, Table 6 shows that an establishment receiving a second inspection that is not categorized by OSHA as a follow up has a .56 probability of being found in compliance, while predicted compliance is virtually 1.0 if that second inspection is designated as a follow up. This result must be interpreted with some caution. Follow-up inspections are focused, primarily devoted to ensuring that specific violations found in previous inspections are corrected. Since they are far less likely to detect new violations than programmed inspections, the follow-up inspection compliance effect is potentially an artifact of this more cursory form of inspection (i.e., the follow-up compliance effect simply reflects that previously cited violations have been corrected). However, in 46 cases in the sample, OSHA conducted a programmed inspection subsequent to a follow-up inspection. In 33 (72%) of these cases, plants were still found to have no violations of machine-guarding standards in these inspections, versus 13 cases where the inspection revealed violations. While not conclusive, this evidence implies that follow ups may have some effects on real compliance behavior beyond their direct impact on previously cited violations.

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[27] Gray and Jones draw on a similarly constructed longitudinal dataset for the manufacturing sector, but they use the total number of violations (rather than compliance with a specific standard) as their metric of compliance. Gray and Jones find that cited violations decrease by half from the 6.3 violations cited in first inspections in their sample. This represents an enforcement impact similar in magnitude to the doubling in compliance found here.

[28] The inclusion of *TOTINSP* dummy variables as proxies for plant-level fixed effects increases the size and statistical significance of the *INSP* and *INSP*3+ coefficients. Gray and Jones (1991b) show that including a variable like *TOTINSP* as a proxy for plant fixed effects does not bias the inspection sequence coefficients, although the coefficients of *TOTINSP* will be underestimated.

The estimated coefficients in Table 5 also predict that compliance is affected by organizational characteristics of the regulated establishments. Table 6 shows that the presence of a union raises the probability of compliance by .15, from .44 to .63 in model 1a, and from .52 to .65 in model 1b. This substantial and statistically significant effect is consistent with labor unions' role in acting as workplace regulatory agents both through OSHA and through their collective bargaining activities (Weil, forthcoming). The coefficients for establishment size are not statistically significant and imply small impacts of size on compliance, given that the probability of compliance increases from .58 for average-sized plants to .61 for those one standard deviation above the mean size. The larger coefficient of the *MULTI* variable indicates, however, that multiplant firms are more likely to comply with OSHA standards than comparable single-site firms.[29]

□ **Explaining compliance responsiveness.** Section 3 predicted that custom woodworking establishments should be relatively unresponsive to OSHA inspection pressures, given the low level of inspection probabilities and observed fines and the relatively high costs of compliance. Yet the empirical results in Tables 5 and 6 imply highly responsive behavior, particularly between first and second inspections. There are a number of possible explanations for this degree of responsiveness.

First, as mentioned previously, compliance decisions may be made on the basis of potential, rather than actual, penalties. If plants believe that they will be levied with the maximum possible penalty arising from continuing noncompliance with standards, it becomes more economically rational to comply, even given relatively little scrutiny. This explanation requires believing that plant managers have limited knowledge about actual OSHA penalty policies during the period. Alternatively, it could imply that managers are averse to even the small probability of facing very large penalties once a violation has been cited.

Second, one could explain the responsiveness if OSHA inspections provide firms with information on the benefits of compliance that they would not otherwise have (see Ashford (1976) for this "public good" justification of OSHA technical standards). As a result of the inspection, firms are given information on how they can both comply with the law and reduce costs by improving safety and health practices. While this explanation may be plausible in complex and poorly understood safety or health standards, it seems unlikely that employers would not already perceive the potential benefits of machine-guarding standards.

Third, other organizational factors not included in the model may lead firms to become more responsive to OSHA, beyond the behavior predicted by simple models of profit maximization.[30] The empirical estimates show that union status has a striking positive impact on compliance, as do establishment size and multiplant status to a lesser degree. Characteristics such as the presence of formal safety and health programs, policies, or committees; senior, middle, and lower-level management attitudes toward safety and health; or other aspects of organizational structure (e.g., degree of centralization, production policies, specific human resource practices) might explain some of the observed changes in compliance behavior (see for example GAO (1992)).

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[29] It is interesting to note that the only significant year dummies are the positive coefficients observed during the Reagan administration (1981–1987). During this period, OSHA cut back on citation activity in general, thereby increasing the probability that a plant would be deemed in compliance with standards (hence the positive coefficients). These results are available from the author.

[30] There is an extensive literature on the impact of organizational structure and culture on regulatory behavior. Rather than assume that compliance behavior results strictly from an economic benefit/cost calculus, this literature argues that characteristics of the firm itself will make it more or less receptive to external regulatory pressure. See, for example, March and Simon (1958); Cyert and March (1963); Pfeffer and Salancik (1978); O'Hare (1982); Vaughn (1983); *Yale Law Journal* (1976).

Finally, citation of standard violations may raise the cost from continued noncompliance in other ways. For example, an industrial accident caused by the presence of a standard violation that has not been remediated by an employer may subject the employer to higher liabilities from litigation, workers compensation premiums, or the experience rating of insurers. Several of the woodworking firms surveyed on compliance costs noted that the passage of OSHA raised more general concerns about employer liability for workplace injuries. This suggests that the incentives for compliance with OSHA standards must be considered as part of a suite of larger regulatory pressures formed by workers compensation systems, private insurers, and the civil/criminal justice system (see Shavell (1984) for a discussion of optimal mixes of liability and safety regulation).

5. Conclusion

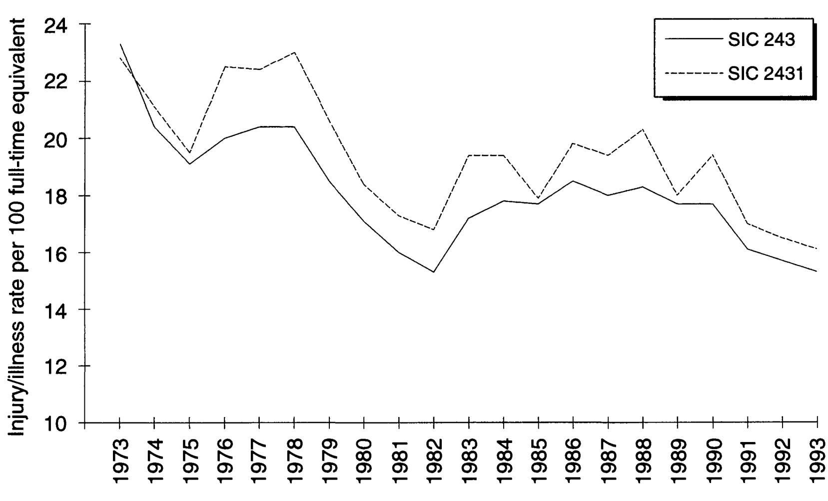
■ The results in this article point to a strong link between OSHA enforcement and compliance, even in an industry that has been subjected to relatively modest albeit typical pressure. This evidence bolsters the findings of earlier studies by Bartel and Thomas (1985) and Gray and Jones (1991a, 1991b) by demonstrating large compliance effects even if one focuses on a specific industry and subset of safety standards.

The impact of OSHA on compliance, however, leads to a more fundamental question about OSHA policy: Does the increased compliance lead to better safety outcomes? The OSHA IMIS data cannot directly provide an answer to this question, since they do not include establishment injury rates. Examining injury rates for two SIC industries (SIC 243 and 2431) closely related to custom woodworking can provide some insights into this question.

Figures 1 and 2 present injury and illness rates for SIC 243 and 2431 for the period 1973–1993. Figure 1 presents total injury and illness rates per 100 full-time

FIGURE 1

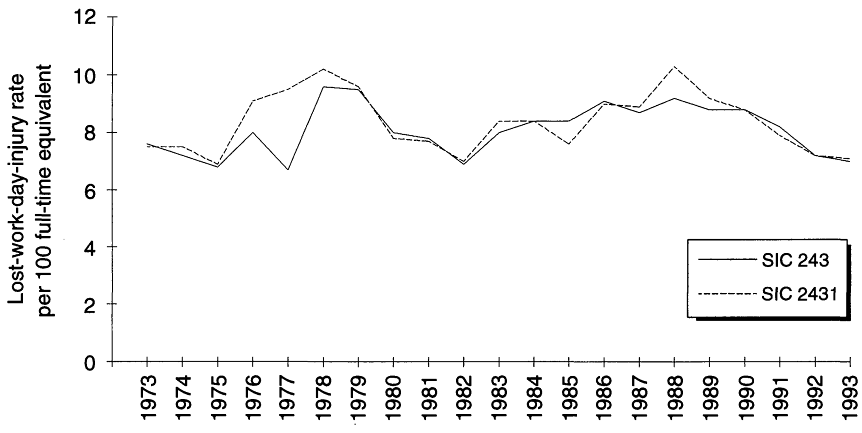
TOTAL INJURY AND ILLNESS RATES, 1973–1993



Source: Bureau of Labor Statistics, *Occupational Injuries and Illnesses by Industry*, selected years.

FIGURE 2

LOST WORK DAY INJURY RATES, 1973–1993



Source: Bureau of Labor Statistics, *Occupational Injuries and Illnesses by Industry*, selected years.

workers.[31] It shows a long-term decline in injury rates from 23.3 in 1973 down to 15.3 in 1993. This would suggest that improving compliance arising from enforcement has manifested itself in lowered injury levels.[32] Figure 2 presents longitudinal evidence on lost-work-day injury rates (i.e., those injuries leading to at least one day lost from work). In contrast to the overall rates presented in Figure 1, lost-work-day rates have not changed appreciably over the period under study.[33]

Taken together, these results may indicate that compliance with machine standards have reduced less-serious injuries but have not appreciably affected more-serious causes of injuries. Alternatively, the annual results may indicate that there is limited spillover of OSHA enforcement on the majority of establishments that have not been subjected to OSHA enforcement. Thus the benefits of compliance are limited to those establishments (40% of the universe in this study) that actually received some scrutiny by OSHA.

The highly responsive behaviors documented in this study suggest that OSHA can be successful in changing employer behavior. The results in Figures 1 and 2, however, strongly suggest that policy-makers must craft standards carefully to ensure that this compliance ultimately leads to desired safety and health outcomes. Further study requires connecting compliance with specific standards directly to injury or illness outcomes: higher compliance may mean little if standards do not result in desired safety or health outcomes.

[31] The OSHA dataset does not include information on injury rates for inspected establishments. Compliance behavior cannot therefore be directly linked to injury performance.

[32] The positive links between enforcement to compliance and compliance to injury rates provide a vehicle to explain enforcement/injury linkages as documented in studies by Cooke and Gautschi (1981) and more recently Gray and Scholz (1990), which show strong impacts of OSHA inspections on injury rates.

[33] In contrast, these results indicating a possible breakdown between OSHA standards and injury outcomes are more consistent with the classic studies of OSHA performance conducted by Viscusi (1979, 1986) and by Ruser and Smith (1991).

Appendix

TABLE A1 Number of Inspections Given Previous and Current Enforcement Outcomes

Number of Inspections Received by Establishment	Number of Inspections Given Violation in Previous Inspection	Number of Inspections Given No Previous Violation	Total Number of Establishments Receiving Inspection	Number of Establishments Receiving No Further Inspection
1	—	—	250	112
2	104	34	138	46
3	33	55	88	31
4	16	41	57	27
5	11	19	30	14
6	5	11	16	6
7	3	7	10	5
8	1	4	5	2
9	1	2	3	2
10	0	1	1	1

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